THE ADMITTANCE OF A MONOPOLE ON AN ELECTRICALLY THICK CONDUCTING CYLINDER

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Practical applications of electrically thin wire antennas often occur in situations where the antenna protrudes from a conducting body whose electrical size is neither so small that its effect can be ignored, nor so large that it behaves, in essence, as a ground plane. Such configurations are found in spacecraft and ships where the satellite, rocket frame or ship's hull has physical dimensions on the order of a wavelength. As a first step in modelling such structures, an electrically thin monopole antenna can be modified to have an electrically thick center and then be excited at the junction of the thin wire and the large conducting body.

An experimental investigation of the admittance properties of monopoles modified by solid conducting cylinders is presented here. In this model an electrically thin monopole extends out axially from an electrically thick right circular cylinder mounted on a large ground plane. The monopole is driven against the top of the cylinder by a coaxial measuring line whose inner conductor extends to form the monopole. To date, only limited analytical and experimental studies of cylinders with heights and radii less than 0.1λ have been accomplished [1],[2]. For the present investigation, seven cylinders with heights up to 0.5λ and diameters greater than λ were fabricated, and admittance measurements as a function of monopole height were made using an r.f. vector voltmeter and a modified impedance probe technique [3]. Over the frequencies of measurement, the diameter of the monopole varied from 0.007λ to 0.015λ and the distance to the nearest edge of the rectangular ground plane was always greater than 4λ.

To validate the experimental technique, the admittance of an isolated monopole was measured over the operating frequency range and compared to previous slotted-line measurements [4] and TEM theory [5]. Good agreement was found and an error bound of ±4% was established on all admittance measurements, with the largest error occurring at the peaks of the admittance curves.

Families of admittance curves in the vicinity of resonance are given in Figs. 1 through 5 for various cylinder dimensions. The effect of the cylinder on the monopole admittance is seen to be pronounced for all cylinder sizes. In Figs. 1 and 2, the presence of the cylinder tends to depress the admittance variation so that the antenna behaves in a broadbanded fashion for relatively small cylinder dimensions. However, as the cylinder size increases, large resonances occur particularly for the case $R = H = 0.25\lambda$. There are also accompanying shifts in the resonant length as the cylinder size changes.

In Fig. 3 it is seen that the presence of a cylinder which has a relatively large diameter ($R = 0.44\lambda$) but is flat ($H = 0.11\lambda$) cannot be ignored since resonant peaks are evident as well as shifts in the resonant lengths. Figs. 4 and 5 give the admittance characteristics for lengthened cylinders with smaller diameters. Again, sharp resonances occur for certain sizes, while broadband properties are evident for other dimensions.

[1] L. L. Tsai, "Dipole Antennas Mounted on a Conducting Sphere or Cylinder," in 1970 IEEE/G-AP Symposium Digest.

[2] D. Lekhyananda, "An Experimental Investigation of Modified Dipole Antennas," Ohio State Univ., Electro-Science Laboratory, Tech. Rept. 2648-1, July 1969.

[3] L. D. Scott and G. S. Smith, "Measurement Techniques for Antennas in Dissipative Media," IEEE Trans. Antennas Propagat., vol. AP-21, pp. 499-507, July 1973.

[4] R. B. Mack, "A Study of Circular Arrays, II. Self and Mutual Admittances," Cruft Laboratory Tech. Rept. No. 382, Table 2-3, Harvard Univ., Cambridge, Mass., May 1963.

[5] R. W. P. King, Tables of Antenna Characteristics, pp. 29-34, Plenum Press, New York, N.Y., 1971.

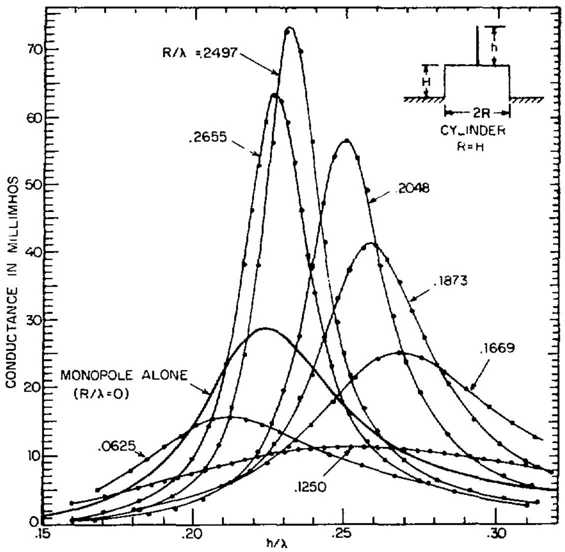

FIG. 1a APPARENT CONDUCTANCE CURVES OF A MONOPOLE ON A CYLINDER R=H (EXPERIMENTAL DATA)

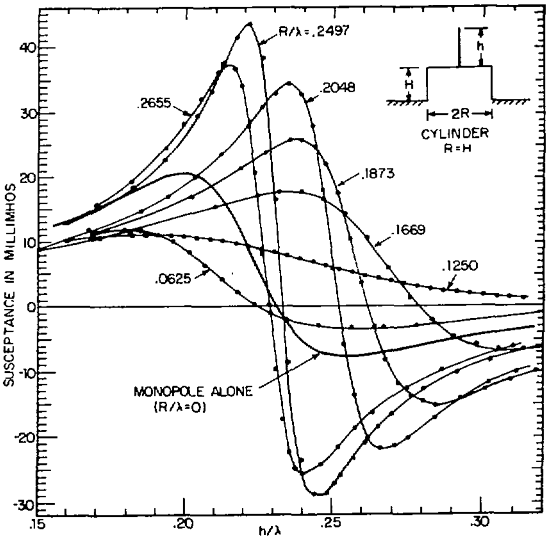

FIG. 1b APPARENT SUSCEPTANCE CURVES OF A MONOPOLE ON A CYLINDER R=H (EXPERIMENTAL DATA)

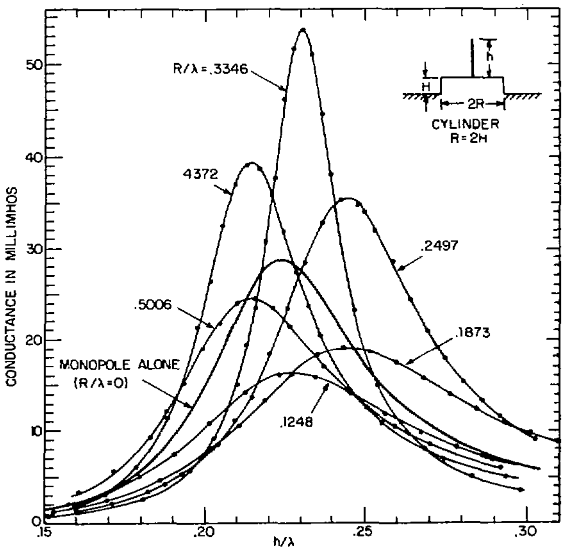

FIG. 2a APPARENT CONDUCTANCE CURVES OF A MONOPOLE ON A CYLINDER R=2H (EXPERIMENTAL DATA)

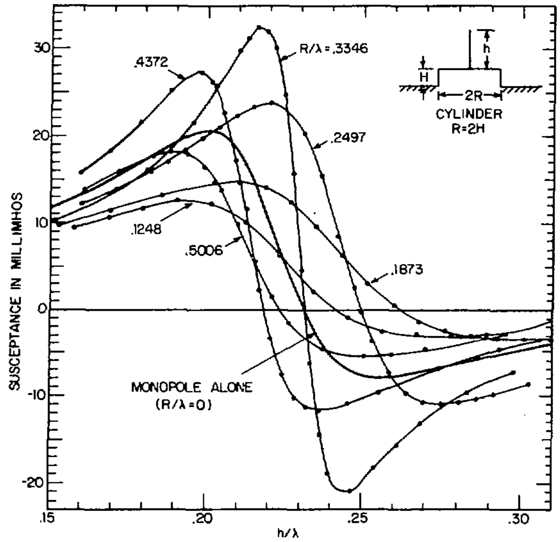

FIG. 2b APPARENT SUSCEPTANCE CURVES OF A MONOPOLE ON A CYLINDER R=2H (EXPERIMENTAL DATA)

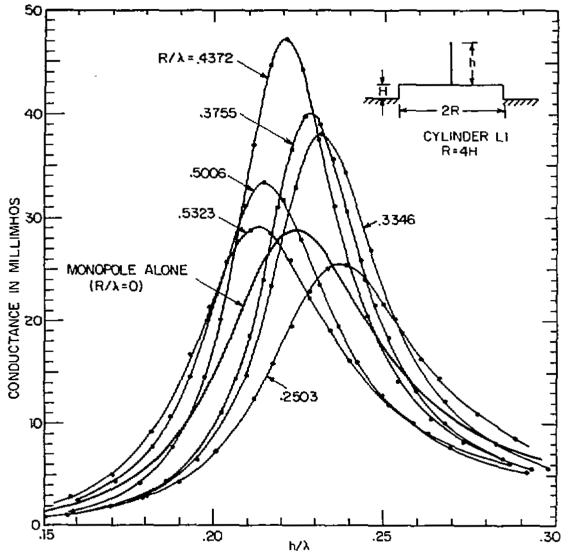

FIG. 3a APPARENT CONDUCTANCE CURVES OF A MONOPOLE ON CYLINDER L1 AS A FUNCTION OF h/λ WITH R/λ=4H/λ AS A PARAMETER (EXPERIMENTAL DATA)

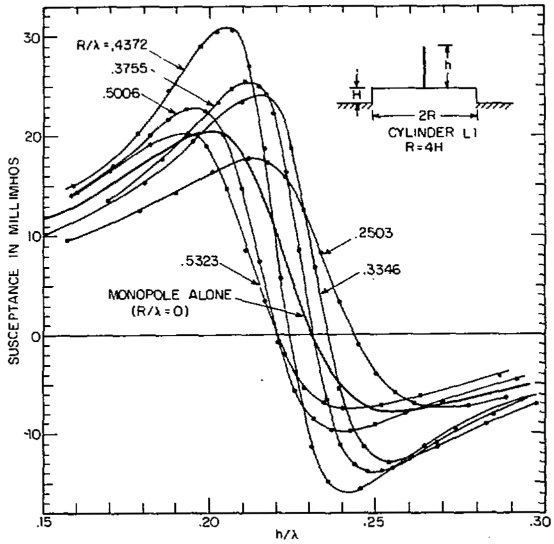

FIG. 3b APPARENT SUSCEPTANCE CURVES OF A MONOPOLE ON CYLINDER L1 AS A FUNCTION OF h/λ WITH R/λ=4H/λ AS A PARAMETER (EXPERIMENTAL DATA)

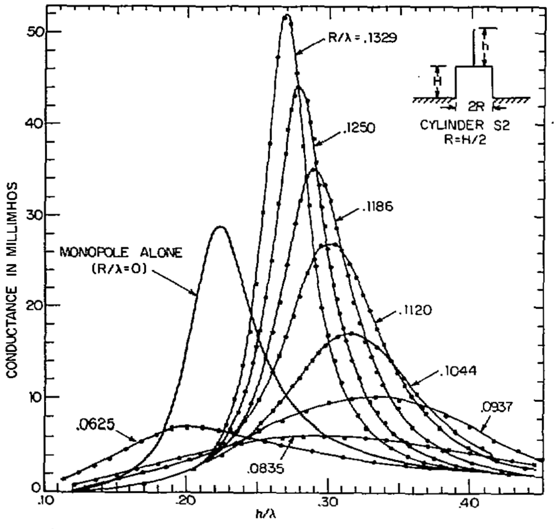

FIG. 4a APPARENT CONDUCTANCE CURVES OF A MONOPOLE ON CYLINDER S2 AS A FUNCTION OF h/λ WITH R/λ=H/2λ AS A PARAMETER (EXPERIMENTAL DATA)

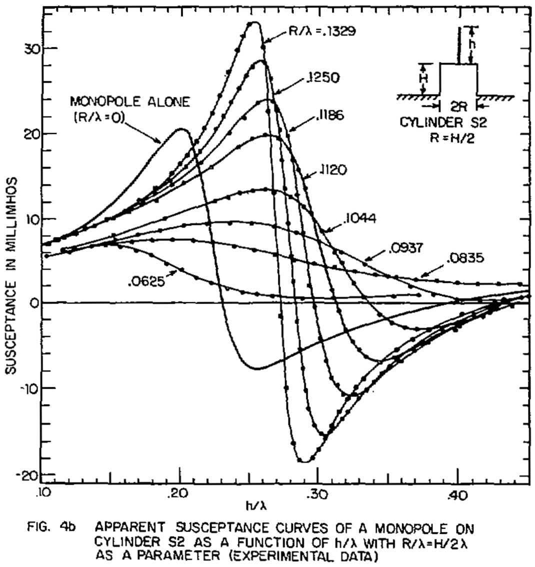

FIG. 4b APPARENT SUSCEPTANCE CURVES OF A MONOPOLE ON CYLINDER S2 AS A FUNCTION OF h/λ WITH R/λ=H/2λ AS A PARAMETER (EXPERIMENTAL DATA)

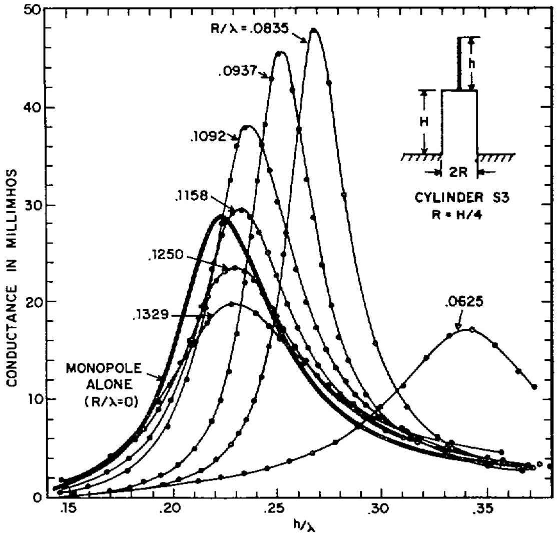

FIG. 5a APPARENT CONDUCTANCE CURVES OF A MONOPOLE ON CYLINDER S3 AS A FUNCTION OF h/λ WITH R/λ = H/4λ AS A PARAMETER. (EXPERIMENTAL DATA)

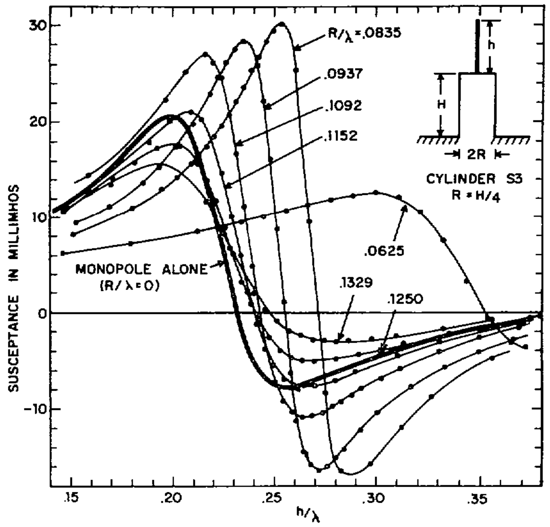

FIG. 5b APPARENT SUSCEPTANCE CURVES OF A MONOPOLE ON CYLINDER S3 AS A FUNCTION OF h/λ WITH R/λ = H/4λ AS A PARAMETER (EXPERIMENTAL DATA)